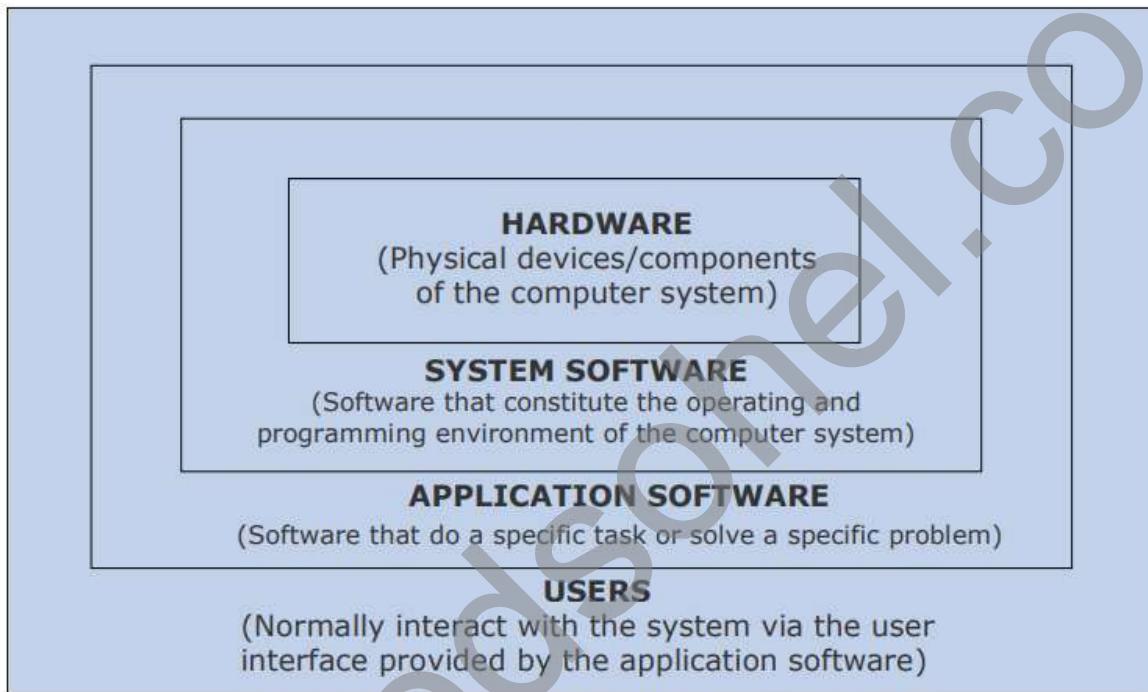


Unit -2: Basic Computer Architecture

2.1 Computer System Architecture

Computer system architecture is representation of relationship among the Hardware, Software (System & Application) and user. It can be depicted as follows:



Hardware:

It is a physical device of computer system which can be touched, seen, moved, dragged. The hardware can be upgraded further as per the requirement of the user. Input output devices certain parts of CPU are hardware (monitor, keyboard, printer, ram, motherboard, speaker, network cards etc). Hardware is onetime expense thing which does not require to spend money until the hardware device stop working.

Software:

It is collection of programs where program is a sequence of instructions written in the language which computer can understand. Like hardware it is also important for computer system to work with hardware. Both hardware and software are complementary to each other. Rather comparing to hardware, software is continuing expense thing. It may be differing in terms of price as per the requirement of user as well as working of itself. It can be categorized in System Software and Application Software.

- **System Software**

It is designed for handling the operation and extending the processing capability of the computer system. It makes computer system operation more effective and efficient.

System software helps for operating the hardware components together as well as supporting the development and execution of the application programs. Some example of system software: Operating Systems, utility programs, compilers/interpreters etc.

- **Application Software**

It is a set of programs which are designed to some specific task or some special job. It can further classify in the two types: general purpose application software and special purpose application software. General purpose application software can be used for very common need like word processing, spread sheets etc. Special purpose application software is specially designed for solving special problems or for performing specific task with use of some particular language of computers. Eg. Billing System, Hotel Management System.

User:

We as a user can operate on the computer system through some software by the means of application software through system software on the computer hardware.

So as per the architecture shown above it works in hierarchy. User cannot use computer hardware directly without the system software and application software.

2.2 Hardware Components

2.2.1 Motherboard

- Main circuit board which is directly / indirectly connected to each part of PC
- Made up of chipsets
- Different types of motherboard are consisting more and complex buses and extra parts which differs in the rate
- Most commonly found parts on the motherboard are: CPU Chip, Co-Processor Chip, Memory Chips, Expansion Slots, Buses, System Clock, ROM Bios, Battery, Ports, NIC, SMPS etc.



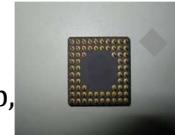
CPU Chip

- Main component of motherboard
- Varies from PC to PC according to models
- It processes the data and controls the function of PC



Co-Processor Chip

- Helps the CPU chip
- There are various Co-Processor chips like math co-processor chip, logical co-processor chip



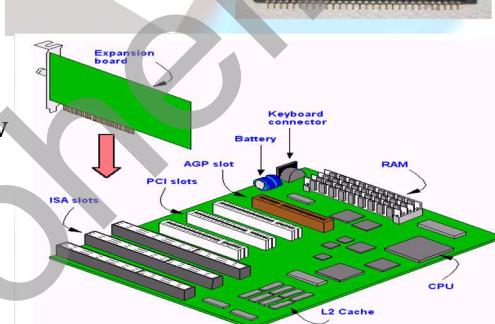
Memory Chips

- Physically installed on the motherboard by 3 different methods.
- DIP: Dual Inline Packaging Method
- SIMM: Single Inline Memory Module Package
- SIPP: Single Inline Pin Package



Expansion Slots

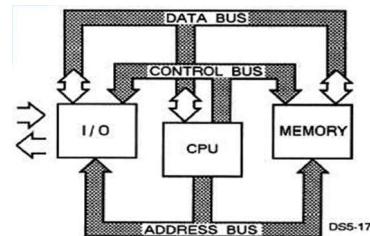
- Connectors on the motherboard which allow us to connect extra cards like: sound card, graphics card, hard disk.



Buses

Different colored lines plotted on the motherboard which moves the information from one part of computer to the other part of computer.

Following are the three components of a bus: –



- The **address** bus, a one-way pathway that allows information to pass in one direction only, carries information about where data is stored in memory.
- The **data** bus is a two-way pathway carrying the actual data (information) to and from the main memory.
- The **control** bus holds the control and timing signals needed to coordinate all of the computer's activities.

System Clock

- Used to synchronize the activities of the various components of computer.

ROM BIOS

- Stores the System Programs which performs supervisory and support tasks in computer.

Battery

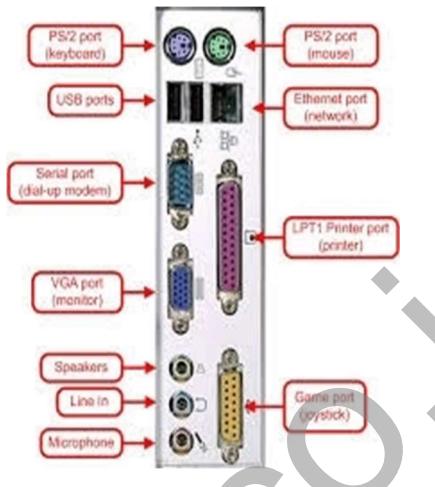
- Used to power clock and BIOS.

Ports

- Used to connect devices to the Computer

NIC

- Network Interface Card.
- Allows the computer to connect to the Network



SMPs

- Switched Mode Power Supply
- An electronic Power supply unit which works as switching regulator.
- It turns the load current ON and OFF to the internal parts to stabilize the output voltage.

2.2.2 Types of Processors

CPU:

CPU is known as brain for every ingrained system. CPU comprises the arithmetic logic unit (ALU) accustomed quickly to store the information and perform calculations and Control Unit (CU) for performing instruction sequencing as well as branching. CPU interacts with more computer components such as memory, input and output for performing instruction.

GPU:

GPU is used to provide the images in computer games. GPU is faster than CPU's speed and it emphasis on high throughput. It's generally incorporated with electronic equipment for sharing RAM with electronic equipment that is nice for the foremost computing task. It contains more ALU units than CPU.

The basic difference between CPU and GPU is that CPU emphasis on low latency. Whereas, GPU emphasis on high throughput

S.NO	CPU	GPU
1.	CPU stands for Central Processing Unit.	While GPU stands for Graphics Processing Unit.
2.	CPU consumes or needs more memory than GPU.	While it consumes or requires less memory than CPU.

3.	The speed of CPU is less than GPU's speed.	While GPU is faster than CPU's speed.
4.	CPU contain minute powerful cores.	While it contain more weak cores.
5.	CPU is suitable for serial instruction processing.	While GPU is not suitable for serial instruction processing.
6.	CPU is not suitable for parallel instruction processing.	While GPU is suitable for parallel instruction processing.
7.	CPU emphasis on low latency.	While GPU emphasis on high throughput.

2.2.3 Understanding the Processor speed

Normally when we go for purchasing any computer kind of electronic gadget we are more concern for the processing speed of the device. CPU speed is basically **Clock speed**. The more cycles that a computer's central processing unit is able to complete per second, the faster data is able to be processed. The faster data can be processed, the faster the computer can complete a task. This means that a computer with a fast processor speed can complete more tasks in the same amount of time than a computer with a slow processor, and that more applications can be running at the same time. Some applications are processor-intensive, which means that they require a great deal of data to be processed in order to operate.

Usually measured in Hz (Herts as in number per second). These days CPUs tick at billions per second, with the prefix G (for giga) ... so you see CPUs in the range of between 1GHz and 4GHz.

While often limited by other reasons, a 3.0Ghz processor is roughly twice as fast as a 1.5Ghz processor. One gigahertz represents a processor's ability to perform a billion – 1,000,000,000 – operations per second¹, and a megahertz is 1000 times less, or one million operations per second. Thus, an older 500Mhz processor would be considered one third the speed of a 1.5Ghz processor.

Processor speed is impacted by several factors. These include circuit size, die size, cache size, efficiency of the instruction set and manufacturing variables. Smaller chips usually result in faster processor speeds because the data has less distance to travel, but smaller chips also result in greater heat generation, which needs to be managed.

2.2.4 Memory

- Computer's Memory is complicated System.
- The memory refers to the physical devices used to store programs (sequence of instructions) or data on a temporary or permanent basis for use in a computer or digital electronic devices.

- It is made up of large number of cells where each cell stores a bit (binary no 0 or 1).
- The computer memory is used from starting the PC to turning off the PC.

Storage Evaluation Criteria

Capacity:

- Total amount of data that can be stored / loaded on the storage unit.
- Capacity of Primary storage device is less than the secondary storage device.

Access Time:

- It is a time needed to locate and retrieve the stored data from the storage unit in response to any instruction.
- Access time of Primary storage device is faster than the secondary storage device.

Cost per bit of storage:

- It is the cost of the storage unit for a given storage capacity.
- Cost per bit of Primary storage device is higher than the secondary storage device.

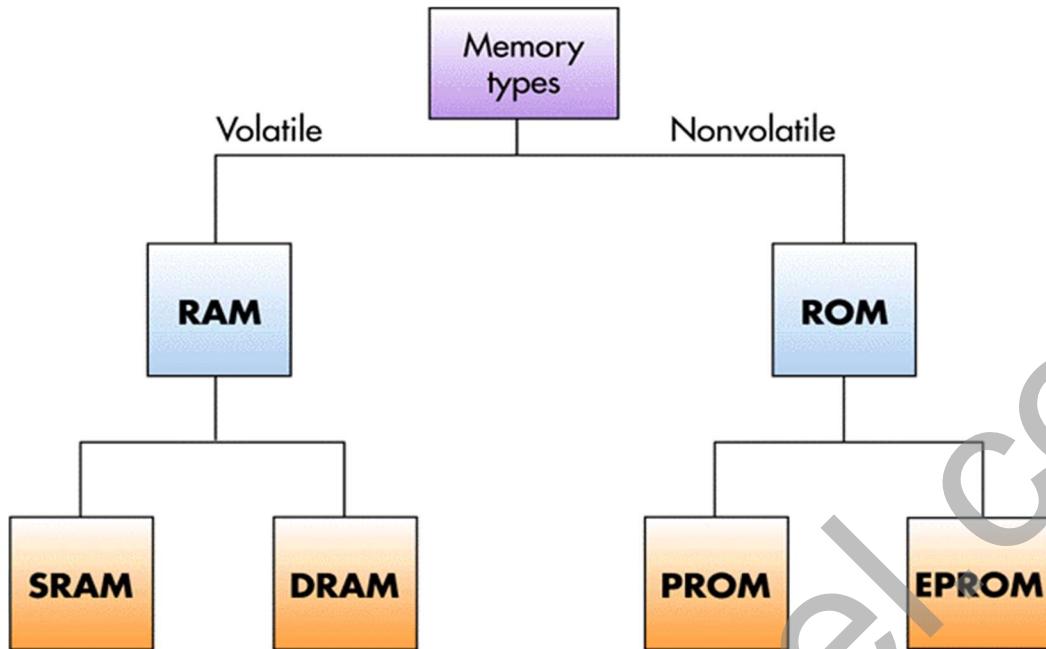
Volatile:

- If a storage unit can hold the data even if the PC turns off or power interrupts, it is known as non-volatile memory.
- If a storage unit loses the data when the PC turns off or power interrupts, it is known as volatile memory.

Random Access:

- If the time to access the data from the storage unit is independent of the location of the storage unit, it is called the Random Access or RAM.
- Locations of the RAM are easy to access as well as it takes the same amount of time
- Primary storage units are having the random access at most whereas the secondary storage unit uses the pseudo -random access.

Types of Main / Primary Memory



Random Access Memory (RAM)

- Basically primary memory of computer is known as RAM
- It is made up of small ICs on it.
- The motherboards are normally made in such a way that we can increase the memory if we want just by adding more capacity RAM.
- It is a volatile memory.
- When the power turned off the data on RAM are erased.
- Its cost per bit storage is higher than secondary memory.
- Available in small sizes : 512mb, 1gb, 2gb. 4gb etc.
- It is available in two techniques: SRAM and DRAM



Static Random Access Memory (SRAM)

- Easy to understand
- Similar to flip flop
- Advantage: It is high speed
- Disadvantage: Power Consumption and Heat

Dynamic Random Access Memory (DRAM)

- Complex mechanism
- Alternative for SRAM
- Advantage: Uses Less power

Example Memory Technologies

Technology	Description
DDR-DRAM	Double Data Rate Dynamic RAM
DDR-SDRAM	Double Data Rate Synchronized Dynamic RAM
FCRAM	Fast Cycle RAM
FPM-DRAM	Fast Page Mode Dynamic RAM
QDR-DRAM	Quad Data Rate Dynamic RAM
QDR-SRAM	Quad Data Rate Static RAM
SDRAM	Synchronized Dynamic RAM
SSRAM	Synchronized Static RAM
ZBT-SRAM	Zero Bus Turnaround Static RAM
RDRAM	Rambus Dynamic RAM
RLDRAM	Reduced Latency Dynamic RAM

Read Only Memory (ROM)

- 1 kind of RAM which is non-volatile.
- It is a chip which stores the data permanently and cannot be changed easily by user programs.
- The data are stored by using the fuse-links, which burnt the data permanently on the chip; since it is known as burnt-in data.
- User can't change the data.
- It is also known as field stores, permanent stores or dead stores.
- The data stored on it; are used frequently.
- In complex structures the micro program are used to read low-level machine functions and reading the data on ROM.
- System boot program is such a micro program.
- The user programmed ROMs are basically divided in two categories as mentioned below:
 - ❖ Non-Erasable
 - ❖ PROM
 - ❖ Erasable
 - ❖ EPROM
 - ❖ EEPROM
 - ❖ UVEPROM / FLASH

Programmable Read Only Memory (PROM)

- These type of ROMs are categorized in Manufacturer Programmed ROM and User Programmed ROM.
- The **manufacturer PROM** is usually burnt by the Manufacturing company which comes with certain electronics equipments.
- For eg.: System Boot Program, Printer controller software in printers.
- **Manufactured PROMs** are basically used when the demand is high.

- **Manufactured PROMs** can't modify by the user.
- In the user PROM, the user can write or store the data on it.
- User can write such micro program for performing specific tasks, which are commonly known as PROM.
- After creation the user PROM can be used as many as time the user wants.
- The user PROM is basically generated by a special type of device which is known as a PROM Programmer.
- After creation it is generally treated as ROM only.
- Once the PROM is designed; it can't be altered or never losses the data even if power fails.
- It is non-Volatile Memory,

Erasable Programmable Read Only Memory (EPROM)

- Disadvantage of ROM / PROM is the data can't altered.
- The EPROM overcomes this problem.
- As the name indicates; the data can be erased.
- At the time of use the user can only read the data.
- It is basically used for R&D personnel who frequently changes the micro program for testing the efficiency with new program.
- In most cases it is treated like ROM where the changes are never to be happen, or happens rarely.
- It is categorized is two type: EEPROM and UVEPROM.
- In **EEPROM(Electrically EPROM)**; the stored data are erased by using the high voltage electric pulses.
- In **UVEPROM(Ultra-Violet EPROM)**; the stored data are erased by using the ultra violet light.
- The EEPROM is easy to use in comparison of UVEPROM.
- EEPROM is also known as Flash memory as it is easy to alter the data on it.(USB devices, Pen Drives)

2.2.4 Storage Devices

Hard Disk

A **hard disk drive** (sometimes abbreviated as a **hard drive**, **HD**, or **HDD**) is a non-volatile data storage device. It is usually installed internally in a computer, attached directly to the disk controller of the computer's motherboard. It contains one or more platters, housed inside of an air-sealed casing. Data is written to the platters using a magnetic head, which moves rapidly over them as they spin. Internal hard disks reside in a drive bay, connected to the motherboard using an ATA, SCSI, or SATA cable. They are powered by a connection to the computer's PSU (power supply unit).

To install a computer operating system, a hard drive (or another storage device) is required. The storage device provides the storage medium where the operating system is installed and stored.

A hard drive is also required for the installation of any programs or other files you want to keep on your computer. When downloading files to your computer, they are permanently stored on your hard drive or another storage medium until they are moved or uninstalled.

Types of Hard disk

- ▶ They are made up of rigid metal platters & comes in many sizes
- ▶ Depending on how they are packed, they are of 3 types:
 - **Zip/Bernoulli Disk**
 - ▶ It consist of single hard disk platter encased in a plastic cartridge.
 - ▶ The disk is 3 ½ inch and has a storage capacity of 100 MB.

Structure of Hard disk



- ▶ Its disk drive called Zip drive may be of portable or fixed type.
- ▶ Fixed type is a part of computer system, permanently connected to it.
- ▶ The portable type can be brought and connected to the when needed.
- ▶ It can be easily loaded or unloaded.

◦ **Disk Pack**

- ▶ It consist of multiple hard disk platters mounted on a single central shaft.
- ▶ All disks rotate together with the same speed.
- ▶ Its disk drive has a separate read/write head for each surface.
- ▶ Its disk drive is of interchangeable type.
- ▶ This gives unlimited capacity of data storage.

◦ **Winchester Disk**

- ▶ It consist of multiple hard disk platter, mounted on a central shaft.
- ▶ It is of fixed type.
- ▶ It has limited capacity storage but have larger than disk pack.

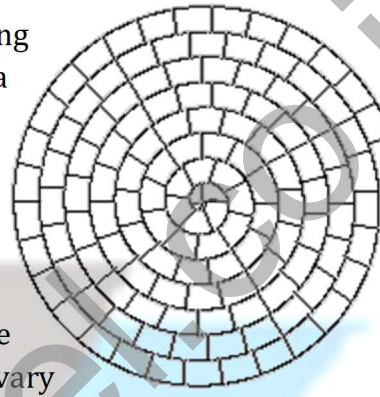
Optical Disks

All read and write activities are performed by light. All recording information stores at an optical disk. As per the opinions of data scientist that compact space is most useful for huge data storage. Their big advantages are not more costly, light weight, and easy to transport because it is removable device unlike hard drive.

All data is saved like as patterns of dots which can be easily read with using of LIGHT. Laser Beam is used like as "Light Source".

The data is read while bouncing laser beam on the surface of storage medium. Laser beam creates the all Dots while reading process, but it is used with high power mode to mark the surface of storage medium, and make a dot. This entire process is also called the "Burning" data onto Disc.

It has one long track starting at outer edge and spiraling inward to the centre. It causes slower random acces of data than in case of concentric tracks, but is suitable for reading sequential data. Spiral track of optical disk is divided into equal length sectors. Sectors of magnetic disk were of different length. Those near centre are small. Using all sectors of equal length, allows data to be packed at maximum density. But it also required complicated drive mechanism because the rotation speed of the disk must vary with the radius.



Storage capacity of an optical disk

$$\begin{aligned} &= \text{Number of sectors} \\ &\times \text{Number of bytes per sector} \end{aligned}$$

The most popular optical disk uses a disk of 5.25 inch diameter with storage capacity of around 650 Megabytes

CD-ROM

CD-ROM stands for "Compact Disc Read Only Memory", and CD-ROM comes in the "Random Access" category's devices. These types of disc can capable to store almost 800 MB of digital data. These data can't discard by mistaken.

DVD-ROM

DVD-ROM stands for "Digital Versatile Disc – Read Only Memory", and it also comes in the "Random Access" category's devices. DVD-ROM discs can store data up to 4.7 GB, but Dual Layer DVD device's storage capacity is double. These types of disc are used to store ultra quality video.

Blue Ray

Blue Ray discs are totally replaced by DVDs, because these discs are capable to hold data up to 25-50 GB, as well as double layer Blue Rays discs can store double data. Due to high storage capacity, Blue Ray discs are used to store HD (High Definition) videos.

HD DVD

HD DVD stands for “High Density DVD”, and these devices are capable to store data up to 15 GB (Dual Layer HD DVDS have storage capacity double). High-Density DVD discs are also used to hold HD Videos.

DVD-RAM

DVD-RAM stands for “DVD-Random Access Memory”, and it is able to Re-Write data. DVD-RAM are available in market like as floppy-disc style case. These types of discs have storage capacity of data similar to DVD (up to 4.7 GB).

Advantages of Optical Storage Devices

- It is capable to store vast amount of data.
- Affordable price
- It can be recycled (Re-used).
- It has ultra data stability.
- Countable/uncountable storage units
- Best Durability, Transport-ability, and archiving.

Disadvantages Optical Storage Devices

- Some traditional PCs are not able to read these disks.
- It is getting trouble while recycling.

USB Flash Drive

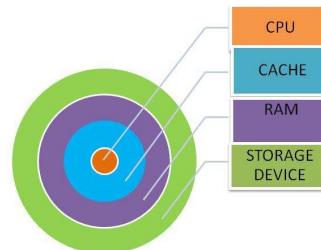
Also known as a thumb drive, pen drive, flash-drive, memory stick, jump drive, and USB stick, the USB flash drive is a flash memory data storage device that incorporates an integrated USB interface. Flash memory is generally more efficient and reliable than optical media, being smaller, faster, and possessing much greater storage capacity, as well as being more durable due to a lack of moving parts.

2.3 Concept of Cache Memory and Virtual Memory

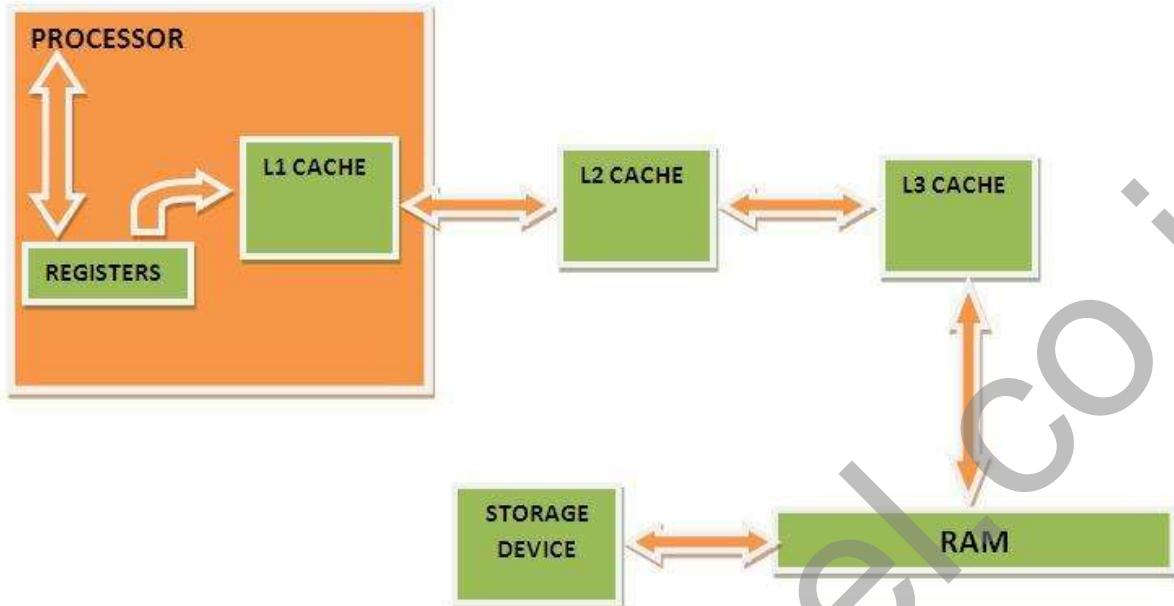
Cache Memory

Cache memory is computer memory with very short access time used for storage of frequently used instructions or the data from the storage devices of computer like HDD.

When an application starts or data read or write starts first of all it is being searched with the storage device of computer like HDD or CDROM (magnetic or optical drives). Then this operation shift from the storage device to the faster device RAMS which normally is Dynamic RAM. Then they are served with the cache memory which is actually a RAM of static type (SRAM) more costly and faster than the RAM. This cache memory is used for transmission of such frequently required data to the CPU instead of using RAM or storage devices each time.



This cache memory is further divided in three segment or 3 levels.



The system has cache of three levels (level means that overall cache memory is split into different hardware segments which vary in their processing speed and memory). From RAM data is transferred into cache of 3rd level (L3 cache). L3 cache is a segment of overall cache memory. **L3 cache** is faster than RAM but slower than L2 cache. To further fasten up the process cache of second order L2 cache are used. They are located at immediate place of processor. But in some of the modern processors **L2 cache** is inbuilt making the process faster. It should be noted that it is not necessary that a system has 3 levels of cache; it might have 1 or 2 level of cache. At the core level is cache of first level that is **L1 cache memory**. The commonly used commands/instructions/data is stored in this section of memory. This is built in the processor itself. Thus this is fastest of all the cache memory.

Virtual Memory

In the earlier days the memory of computers was too small so the programmers were working on some large programs with size restrictions. To overcome the above limitation, the concept of virtual memory was implemented in 1961 by the group of researchers at Manchester, England. It is implemented by the computer and its operating system, which allows the programmers to use large range of memory or storage address for stored data. The computing system maps the programmer's virtual address to real hardware storage address. So the programmer is free from thinking about the size of memory.

In addition to managing the mapping of the virtual address to the original address, the computer implements the virtual memory which manages the swapping between the RAM data (active storage) and the HDD data (passive storage). The amount of data in units is read in fixed size of bytes or no. of byte are known as pages. And this process is known as paging. It reduces the overall access of the physical devices and increases the speed and performance of the system.

Short Questions:

1. How does Computer memory work?
2. What is access time?
3. What are the basic types of memory?
4. Differentiate between primary and secondary memory.
5. What is fixed length memory? Explain.
6. What is variable length memory? Explain.
7. Give full form of: SRAM, DRAM, DDR-DRAM, FCRAM, FPM-DRAM, PROM,EPROM, EEPROM, UV-EPROM
8. What is Virtual Memory? Explain in short.
9. What are the different type of hard disk?
10. What are the different types of optical disks?

Long Question:

1. Explain the Computer System Architecture.
2. Explain motherboard in detail.
3. Explain primary or main memory organization in detail.
4. Explain RAM in detail
5. Explain ROM in detail.
6. Explain various addressing modes of computer memory in detail.
7. What is Cache Memory? Write a short note on that.
8. Explain hard disk in details
9. Explain optical disk in details.